In this table m is the value of the length of the path of the solar rays in passing through the atmosphere in terms of the length when the sun is in the zenith, as computed by Bemporad. In the following column m is multiplied by the ratio of the atmospheric pressure to standard pressure, or 760 mm. I is the measured intensity of solar radiation, and $I_R{}^2$ is the mean value of the solar constant, I_0 divided by the square of the earth's radius vector in terms of its mean value. The computed atmospheric transmission is obtained from the MONTHLY WEATHER REVIEW, February, 1930, volume 58, page 52, Figure 1. The atmospheric depletion indicated by this computed transmission includes all that Fowle found correlated with pure dry air and water vapor. The difference between the two transmission values must be attributed to depletion by impurities in the atmosphere.

Comparing these differences with corresponding differences for Washington, D. C.; Madison, Wis.; Lincoln, Nebr.; and Davos, Switzerland, given on page 51 of the REVIEW cited above, it is seen that the atmosphere at Mount Evans, Greenland, is relatively free from dust at all seasons of the year, as we would expect it to be.

RAIN-GAGE FUNNELS OF DIFFERENT DEPTHS

By JOHN GLASSPOOLE, M. Sc., Ph. D.

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With reference to the article on "Rainfall catch as affected by different depths of funnels in the rain gage,"[1] it may be of interest to refer to some of the experiments which have resulted in the adoption of the deep-funnel gage as the standard pattern in the British Isles.

At the majority of the official stations of the Meteorological Office the 8-inch gage is used, in continuation of a practice which dates back to about 1870. According to the current specification the funnel has vertical walls $5\frac{3}{4}$ inches deep. By far the greater number of gages in use in the British Isles are, however, 5 inches in diameter. In the case of the standard "Snowdon" gage the diameter is 5 inches and the depth of the vertical walls is about 4 inches. In the Meteorological Office version of this gage the depth of the vertical walls is $4\frac{11}{16}$ inches and the funnel proper slopes at $33\frac{1}{2}°$ to the horizontal. The rain is collected in a bottle holding about $3\frac{1}{2}$ inches, standing in a copper can, the total capacity of which is about 9 inches. The inner can stands in an outer can, on to the top of which the funnel fits. The base of the outer can is splayed so that the gage can be fixed firmly in the ground at such a depth that the rim is exactly 1 foot above the surface. Somewhat similar gages, but of larger capacity are used for monthly measurements. In these gages a dip rod is used, but only for the purpose of giving a rough check reading. The actual measurement is made by pouring the water into a cylindrical glass measure graduated in inches and tenths. For daily observations, measuring glasses with taper bases are used. These glasses are subdivided to 0.01 inch or 0.1 mm., the former have an additional graduation at 0.005 inch for the purpose of making it easy to decide whether a small amount is to be counted as a "trace" or as 0.01 inch. This is important because in the latter case the day ranks as a rain day. These particulars are given in some detail because it is important, in this connection, to remember that the instruments used in the British Isles are very different from those used in America.

According to Mr. R. H. Scott, a former head of the Meteorological Office, the deep-funnel gage was invented by Quetelet. A gage with a vertical wall of 6.3 inches is described in "Sur le Climat de la Belgique, cinquieme partie" by Quetelet, published in 1852. The introduction of the deep-funnel gage in the British Isles was due mainly to Mr. G. J. Symons, the founder of the British Rainfall Organization, now incorporated in the Meteorological Office. It was first used about 1864, and subsequently on Mount Snowdon. It became known as the Snowdon pattern, and has gradually replaced gages of the British Association and Howard patterns, which have shallow funnels. Even at the present time, however, some 1,500 of the 5,000 voluntary observers in the British Isles use a gage of nonstandard pattern, of which the vertical walls above the funnel are usually less than half an inch in depth.

It must be admitted at the outset that in the normal conditions prevailing in the British Isles, the use of a deep-funnel gage makes no great difference to the measured annual total. It is not possible by a critical comparison of the monthly or annual records in a given locality to detect the returns from shallow-funnel gages. This generalization is supported by the records from stations which have gages of both patterns. Three typical cases are quoted below:

Station	County	Period of observation	Mean annual values			
			Shallow funnel	Snowdon funnel	Difference	
			Inches	*Inches*	*Inches*	*Per cent*
Tenterden	Kent	1876–1921	28.28	27.76	+0.52	+1.9
Swinton House	Berwick	1914–1921	26.16	26.03	+.13	+.5
Purley	Surrey	1907–1920	31.16	31.48	−.28	−.9

The differences year by year depart little from these mean values. It should be noted, however, that if any obvious error occurred—e. g., during snow—the same amounts were generally adopted for both gages. Some observers have noted that the shallow gage gave a slightly larger number of rain days.

It has been possible, however, to attribute inconsistencies in the *daily* readings at adjacent stations to the use of a shallow-funnel gage at one or more of them. During periods of snow and of intense rain or hail, the standard gage invariably retains a better sample of the precipitation. Although there is obviously more risk of loss with the shallow-funnel gage by outsplashing from the funnel during intense rain or hail few comparative readings are on record. Even when such readings are available some doubt often exists as to whether they are strictly comparable owing to such precipitation being particularly local.

Some of the earliest experiments in the British Isles on this subject were made by Colonel Ward, at Calne (Wiltshire) during the years 1865 to 1868.[2] Colonel Ward found that during the summer six months a shallow

[1] MONTHLY WEATHER REVIEW, July, 1930, vol. 58, pp. 282–283.

[2] British Rainfall, 1874, pp. 25–34.

funnel gage (of copper) and a Snowdon funnel gage (of japanned iron) gave almost identical totals, while during the winter the former gave 0.136 inch more per month. The annual total was about 30 inches. During March and April the shallow-funnel gage gave on the average 0.027 inch more per month, during the five summer months 0.035 inch less, and during the remaining winter months as much as 0.150 inch less. Apart from the winter months, when the differences were due mainly to snow, the differences were very small. The relative increase in the catch of the Snowdon gage from the spring to the summer months is associated with the general increase in the intensity of the rainfall. The Snowdon gage had therefore marked advantages in winter and in summer. There was, however, a small defect due to the larger surface of the funnel which resulted in greater loss by evaporation. This was apparent only in March and April, when showers alternating with sunshine are a feature of the weather of the British Isles. Symons was satisfied that the advantages of the Snowdon gage far outweighed this small defect,[3] and this conclusion has been borne out by subsequent experience.

A series of comparative readings were subsequently made by Colonel Ward at Rossiniere, Switzerland, with two copper gages with the rims 1 foot, 6 inches above the ground and 9 inches apart. On 30 days during the period October, 1873, to February, 1875, the precipitation took the form of snow, which lay on the ground as soon as if fell. In each case the depth of snow was less than would fill the deep funnel. On these occasions independent estimates of the precipitation were made by inverting the funnel over undrifted snow and measuring in the ordinary way after melting. The comparative readings for these days were: Shallow-funnel gage, 2.67 inches; Snowdon funnel, 5.56 inches; and the independent methods, 5.43 inches.[4] It was concluded that good estimates of snowfall could be made by the use of the Snowdon funnel gage, and that serious losses resulted with the shallow-funnel gage.

Among the numerous experiments with different types of gages carried out in the British Isles, no other comparative readings appear to have been made with funnels of depths other than those already quoted.[5] Reference should, however, be made to the experiments recently carried out by Mr. A. J. Bamford in Ceylon, using deep-funnel and shallow-funnel gages.[6] These experiments were made with special reference to losses by evaporation and to the use of bottles in gages, and they confirm in general the results already given.

In the experiments made in the British Isles using funnels of different depths, the differences in the catch have not been correlated directly with the strength of the wind, as in America.[7] As a matter of fact some of the largest differences in the catch occurred with high wind, but in general there was little correlation between the differences and the strength of the winds. Possibly this is due to the gages in the British Isles generally being in a reasonably sheltered site, since the standard height of the rim of the gage is 1 foot above the ground.

[3] British Rainfall, 1874, pp. 39-40.
[4] See British Rainfall, 1874, face p. 29.
[5] A summary of the experiments made in the British Isles is given in the article on "The Development of Rainfall Measurement in the Last Forty Years," by Dr. H. R. Mill, British Rainfall, 1900, pp. 23-41, although curiously the question of the depth of the vertical funnel is not mentioned.
[6] The Meteorological Magazine, 1930, pp. 81-87.
[7] MONTHLY WEATHER REVIEW, July 1930, vol. 58, pp. 282-283.

EARLY OPENING OF THE NEW YORK STATE BARGE CANAL

By J. H. SPENCER

[Weather Bureau Office, Buffalo, N. Y.]

The New York State Barge Canal was officially opened this year on April 6, reported to be the earliest in 103 years. The steamer *William Hengerer* and three barges left Buffalo for New York with bonded wheat on the 7th.

There was practically no ice in Lake Erie after March 29. Navigation opened at Buffalo on April 3, with the arrival of the freighter *Coralia* from Detroit loaded with automobiles. The opening of navigation this year was 12 days earlier than the average.

These events reflect the mildness of the winter in this section of the country.

"MICHAEL SARS" NORTH ATLANTIC DEEP-SEA EXPEDITION, 1910

Reviewed by KATHERINE B. CLARKE

(Report on the scientific results of the *Michael Sars* North Atlantic deep-sea expedition, 1910. Edited by Sir John Murray and J. Hjort. Vol. I, Deposit Samples by J. Chumley, pp. 1-12; Physical Oceanography and Meteorology, by B. Helland-Hansen, text pp. 1-115, tables and plates pp. 1-102. Published by the Bergen Museum, Bergen, Norway, 1931.)

This volume is the first in a series on the scientific results of the *Michael Sars* expedition, a series which promises to be an exceedingly valuable contribution to the development of oceanography and associated sciences. Planned chiefly as a biological survey of the North Atlantic, a gratifying amount of geophysical and meterological data of real value was also obtained. Few persons are better qualified by knowledge and experience to write the discussion of these data than the eminent Norwegian oceanographer, Helland-Hansen.

The section on physical oceanography and meteorology has two major divisions, the text and the tables and plates. The text is further outlined in 10 chapters which cover the following topics: Introduction, sea surface and air, subsurface temperatures, salinities and densities (methods), local variations in general, short-period oscillations, the temperatures in the sea, salinities in the North Atlantic, stability, dynamics of the sea, and current measurements. The text is followed by an ample bibliography.

The chief interest from a meteorological viewpoint lies in the discussions of sea and air temperatures, the interaction of ocean and atmosphere, and diurnal, seasonal, and annual variations. Observations were made from June 3 to August 15, 1910. For purposes of statistical compilation these are divided into four series. On Deutsche Seewarte synoptic charts for each day of the cruise the position of the *Michael Sars* is shown. Accompanying graphs give for each day the meteorological conditions observed on the ship.

A very conspicuous positive correlation between surface temperatures and surface salinity was found. Regional variations were the chief cause for great variations in mean surface temperature. The daily period of surface temperature was not as evident as might be expected, but correlated closely with the amount of cloudiness, being more prominent with slight than with extensive cloudiness. A conclusion previously expressed by Helland-Hansen and Nansen, that variations in surface temperature are primarily the result of displacement of the surface